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ORIGINAL PAPER

Feeding performance of *Clostera fulgurita* on three clones of *Populus deltoides*

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Abstract: Poplar leaf defoliator, *Clostera fulgurita* (Walker) larvae were reared on three *Populus deltoides* clones (PL1, PL5 and PL7) in the laboratory. The nutritional indices were computed for working out the relationship between food consumption and growth rate of 3rd, 4th and 5th instar larvae on three clones. The result showed that the consumption index (CI), approximate digestibility (AD), growth rate (GR), relative growth rate (RGR) and efficiency of conversion of ingested food (ECI) decreased with the increase in the age of the larvae. Efficiency of conversion of digested food (ECD) increased with increase in age of the larvae. GR and RGR varied significantly, indicating that larval development was enhanced on PL1 as compared to PL5 & PL7. The values of AD, ECI and ECD were not affected by the different clones. Feeding and growth indices could be useful to define a defoliation prediction model.

Keywords: *Clostera fulgurita*; growth indices; utilization of food; poplar clones

Introduction

Clostera fulgurita (Walker) (Lepidoptera Notodontidae) is a major leaf defoliator of young *Populus* plantations in Punjab, Haryana, Uttaranchal and Uttar Pradesh (Singh and Prasad 1985; Sohi 1990; Thakur 2000). The larvae prefer feeding on young and succulent leaf tissue. A large proportion of young *Populus* plantation is composed of trees which have higher percentage of preferred leaf tissue for larvae and such trees are more susceptible to the defoliator throughout their rotation age. Defoliation of poplar trees results in reduced vigour & growth and increased susceptibility to insect & pathogens, leading to death of the individual terminal shoot or entire tree. Preference of the larvae towards a particular clone/host plant is governed by many factors. It is widely recognized that plant species differ greatly in terms of their suitability as hosts for insect growth, survival and reproduction. Nutritional indices indicate the degree of insect host interaction and the nutritional suitability of the host plant. The larvae of *C. fulgurita* thrive well on different clones grown in the area. For a holistic understanding of insect plant interaction, comprehensive studies on nutritional preference and feeding potential of *C. fulgurita* are needed. Hence, the effect of three popular clones (PL1, PL5 and PL7) on the insect nutrition and growth was assessed in laboratory.

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Materials and methods

Materials

Studies on the consumption and utilization of poplar leaves by *C. fulgurita* were carried out as per standard gravimetric methods described by Waldbaur (1968).Newly hatched larvae (0-24 h) obtained from the nucleus culture were used for the experiment. The larvae were reared on each clone in ventilated plastic vials (30 mm at diameter and 100 mm in height) with a photoperiod of 16:8 (L:D) at temperature regime of (25±2)°C and relative humidity of (80±5)%. *Populus deltoides* clones, PL1, PL5, and PL7, were taken for the study. Leaves from the clones raised under screen house conditions in pots were taken and washed with water before using.

Methodology

The growth and development of *C. fulgurita* larvae on PL1, PL5 and PL7 clones of poplar were studied under "NO Choice" conditions in the laboratory. The newly hatched larvae (90 larvae in all i.e. 30 larvae reared on each of the three clones) of uniform age obtained from the culture were kept in petri dishes with single leaf of each of the three poplar clones. As soon as the larvae entered third instar, leaves (weighed) of the three clones were

provided to the larvae in ventilated plastic vials in different treatments and the larval weight was recorded individually. Ten larvae per replication (one larva per petri dish) were exposed to each clone and they were three replications for each treatment. To work out the corrected weight of the leaves consumed by the larvae in each replication, one leaf (weighed) per petri dish was kept without releasing the larvae. The weight of the leaf was recorded every 24 h. The decrease in weight was attributed to moisture loss. The larvae that died during the course of the experiment were replaced by healthy larvae were reared on the same clone. The moulting of the larvae into the next instar was also recorded based on head capsule exuviae.

Old leaves of each clone in each petri dish were replaced with new leaves (weighed) of each clone at every 24 h after exposure. The unconsumed leaf and the faecal matter in the Petri dish were also weighed. All weights were measured using an electronic balance. This data were recorded from each petri dish for each poplar clone individually. Feeding potential of the defoliator was worked out by calculating the average leaf consumption in the different larval instars and leaf consumption rate was worked out. From these data, the physiological indices (consumption index, growth rate, relative growth rate, approximate digestibility, efficiency of conversion of ingested food and efficiency of conversion of digested food) were calculated for each instar (3-5 instar) on clone (PL1, PL5 and PL7) on basis of the formulae (Waldbaur 1968).

Consumption index (CI):

$$CI = F / T_A \tag{1}$$

where, **F* is the corrected weight of the food eaten; *T* is the duration of feeding period (days); *A* is mean fresh weight of the larvae during feeding period. **F*= [1-*a*/2] [*W*-(*L*+*bL*)], where, *W* is the weight of food introduced; *L* the weight of uneaten food, *a* the ratio of moisture loss to the initial weight of aliquot, and *b* is the ratio of moisture loss to the final weight of aliquot.

Growth rate (GR):

$$GR = G / A \tag{2}$$

where, *G* is fresh weight gain of larvae during feeding period, and *A* is mean fresh weight of the larvae during feeding period.

Relative growth rate (RGR):

$$RGR = G / A_T \text{ or } G_R / T \tag{3}$$

where, *T* is duration of the feeding period (days).

Efficiency of conversion of ingested food (ECI):

$$ECI = W_g / W_1 \times 100 \ \% \tag{4}$$

where, W_g is the weight gained, and W_1 is the weight of food injested.

Approximate digestibility(AD):

$$AD = \frac{W_1 - W_2}{W_1} \times 100 \ \% \tag{5}$$

where, W_2 is weight of feaces.

Efficiency of conversion of digested food (ECD)

$$ECD = W_g / (W_1 - W_2) \tag{6}$$

Mean larval weight (larval period/larval instar):

$$M_1 = \sum L_W / D_l \tag{7}$$

where, L_w is the larval weight, and D_l is the duration of larval period/larval instar.

The nutritional indices worked out for the larval instars and the poplar clones were subjected to analysis of variance. LSD was calculated at 5% level to see the differences among individual effects. Further, correlation coefficients between combinations of parameters were estimated to measure the strength of linear relationship at 5% confidence level. Percentage data in the case of AD, ECI and ECD were normalized before analysis.

Results

Larval instars

Consumption index indicates the relationship between consumption of food (poplar foliage) and body weight (g) of the larvae within specified period (24 h). It was evident from the data in Table 1 that mean Consumption index (C_I) was highest (2.88) in third instar, compared with fourth and fifth instar and it decreased with increase in age of the larvae (Fig. 1). The CI values of 2.88, 2.57 and 2.07 were recorded in third, fourth and fifth instar larvae respectively, which differed significantly from each other.

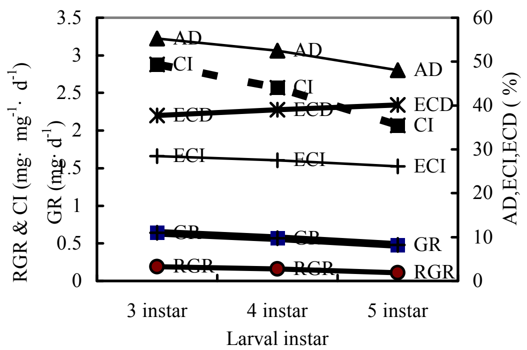

Fig. 1 The trends of physiological indices of different larval instars of *Clostera fulgurita*

The growth rate (GR) explains gain in larval weight in a unit time (24 h). Growth rate directly affects the speed of larval growth, which depends on the food or abiotic factors like temperature and relative humidity. During winter months, the larval growth and development is slow, compared to summer months. The life cycle of most insects is lengthened during winters. The mean value of GR was highest (0.64) in third instar and it decreased with increase in ages of the larvae (Table 1, Fig 1). The GR values of 0.64, 0.57 and 0.47 were recorded in third, fourth and fifth instar, respectively. These values did not differ significantly from each other.

The relative growth rate (RGR) indicates that the digested food is available in accordance to increase in body weight of the insect in a given period of time. The RGR for the larval instars differed significantly (Table 1). Maximum mean RGR was recorded in third instar (0.195), followed by fourth instar (0.157) and fifth instar (0.105).

Approximate digestibility (AD) is a portion of the efficiency of conversion of food. The data revealed a gradual decline in AD in successive instars (Table 1). Mean AD for larval instars was the maximum in third instar (55.28%), followed by fourth instar (52.48%) and fifth instar (48.05%, Fig. 1).

The efficiency of conversion of ingested food (ECI) was an overall index of the insect ability to utilize foliage for growth. The mean ECI value was highest (28.45%) in the third instar larvae, but it significantly decreased in fourth instar and reached a lowest value (26.16%) in the fifth instar (Table 1 and Fig 1).

The efficiency of conversion of digested food (ECD) was an index of the insect to assimilate and convert food into body substances. The ECD varies with the level of intake and nutritional value of food utilized for metabolic activities. The mean ECD value was lowest (37.72%) in the third instar larvae, which significantly increased in fourth instar and was highest (40.09%) in the fifth instar (Table 1 and Fig 1).

Poplar clones

The CI differed non-significantly among the tested clones (PL1, PL5 and PL7) in Table 2. However, it was numerically highest (2.65) in PL5, followed by 2.61 (PL7) and 2.26 (PL1). This indicated that all the three clones were suitable as host plants for *Clostera* larval feeding.

Table 1. Growth and development indices of different larval instars of *Clostera fulgurita* fed on leaves of *Populus deltoides* under laboratory conditions

Larval instar	Larval growth and development indices (Mean values)					
	Consumption index ($mg\ mg^{-1}\ d^{-1}$)	Growth rate ($mg\ d^{-1}$)	Relative growth Rate ($mg\ mg^{-1}\ d^{-1}$)	Approximate digestibility (%)	Efficiency of conversion of ingested food (%)	Efficiency of conversion of digested food (%)
Third	2.88 ± 0.35*	0.64 ± 0.03	0.195 ± 0.04	67.57 ± 2.64	22.68 ± 0.64	37.42 ± 3.07
Fourth	2.57 ± 0.30	0.57 ± 0.03	0.157 ± 0.15	62.93 ± 2.30	21.35 ± 0.52	39.77 ± 4.15
Fifth	2.07 ± 0.29	0.47 ± 0.04	0.105 ± 0.01	55.35 ± 1.93	19.46 ± 0.44	41.54 ± 4.12
LSD at 5 %	0.25	0.02	0.007	(1.15)	(0.32)	(1.77)

Note: * presents Standard Deviation (SD).

Table 2. Effect of different clones of poplar on the larval growth and development indices of *Clostera fulgurita* under laboratory conditions (Pooled analysis)

Clone	Larval growth and development indices					
	Consumption index ($mg\ mg^{-1}\ d^{-1}$)	Growth rate ($mg\ d^{-1}$)	Relative growth rate ($mg\ mg^{-1}\ d^{-1}$)	Approximate digestibility (%)	Efficiency of conversion of ingested food (%)	Efficiency of conversion of digested food (%)
PL 1	2.26 ± 0.25*	0.59 ± 0.02	0.17 ± 0.008	63.88 ± 1.08	21.46 ± 0.26	42.59 ± 2.58
PL 5	2.65 ± 0.10	0.54 ± 0.01	0.15 ± 0.004	61.01 ± 0.50	20.82 ± 0.33	38.25 ± 2.67
PL 7	2.61 ± 0.35	0.56 ± 0.01	0.12 ± 0.008	61.46 ± 2.67	25.24 ± 0.55	37.87 ± 3.68
LSD at 5 %	NS	0.02	0.01	NS	NS	NS

Note: * presents Standard Deviation (SD).

There were significant differences in GRs of the larvae fed on different clones of poplar. GR was minimum on PL5 (0.54) and maximum on PL1 (0.59). PL1 proved significantly more suitable host plant as compared to PL7 and PL5. PL7 and PL5 were equally suitable clones.

Significant differences were observed in RGR of larvae fed on different clones of poplar. RGR was minimum on PL7 (0.12) and maximum on PL1 (0.17). PL7 was the least suitable host while PL1 was the most suitable for larval development.

Approximate digestibility values for *C. fulgurita* larvae reared on different clones were statistically non-significant. Maximum approximate digestibility was recorded on PL1 (63.88%), followed by 61.46% (PL7) and 61.01% (PL5). It is indicated that the foliage of all the clones was equally assimilated by *Clostera fulgurita* larvae.

The differences in ECI values of larvae of *C. fulgurita* reared on different clones of poplar were statistically non-significant (Table 2). However, numerically higher value was recorded on PL1 (21.46%). Foliage of all the clones was equally utilized by the larvae for growth.

There were not significant differences in ECD values of larvae of *C. fulgurita* reared on different clones. Maximum E_{CD} was on PL1 (42.59%), followed by PL5 (38.2%) and PL7 (37.87%). Foliage of all the clones was efficiently converted into body substances by the larvae.

Pooled analysis of the indices indicated that all the clones were equally suitable for larval growth and development. However, the respective larval instar had the varied efficiency in utilizing the foliage of *Populus deltoides*. In the third instar larvae, there was most efficiency in w.r.t CI, GR, RGR, AD and ECI. In the fifth instar larvae, there was most efficiency in converting the assimilating food into body substances

Discussion

Consumption index, growth rate, relative growth rate, approximate digestibility and efficiency of conversion of ingested food were found to vary significantly in third, fourth and fifth instars. The CI, GR, RGR, AD and ECI were highest in the third instars and they were significantly decreased in the fourth instar and were the least in the fifth instar. The efficiency of conversion of digested food followed the opposite trend i.e. the highest index value being in the fifth instar and the lowest in the third instars.

Kumar and Ahmad (2000) also reported that CI decreased from (28.60±1.84) first instar to fifth instar (0.72±0.02) of *Orgyia postica* larvae on Paulownia leaves. The decline in the CI in successive instars is due to the increasing body weight of the larvae and has been corroborated by many workers (Bailey and Singh 1977; Vats et al. 1977; Mackey 1978; Vats and Kaushal 1980 and Slansky and Scriber 1981). However, highest CI was observed in fifth instar (8.60) and lowest in first instar (0.82) by Ahmad et al. (2002) but these observations were based on the body length of the larvae.

Growth rate was significantly higher in third instar than the other instars. Similar, results have been recorded in lepidopterous larvae. However, opposite trends of GR with increasing age of larvae were reported by Ahmad et al. (2002) in *C cupreata* based on body length of the larvae.

The RGR decreased with increase in age of the larvae (Fig 1). Similar, observations have been reported by Ahmad et al. (2002) on *C. cupreata* based on body length of the larvae. Kumar and Ahmad (2000) also corroborated the trend in case of *Orgyia postica* on Paulownia. The trend of RGR in different larval instars showed that a greater amount of consumed food was utilized during initial stages of larval development to enhance the growth of the body.

The decline in AD values with age of the larvae was attributed to varying food habits and efficiency of food utilization in different larval instars. It was probably due to the fact that smaller instars (1-3) chewed off smaller pieces of food resulting in enhanced digestibility for the foliage. Young leaf feeders might also ingest a greater proportion of easily digestible broken tissues. The young larvae are more selective feeders and choose more digestible foliage from the intravenous portions of the fresh and young leaves, compared with older larvae (Bailey 1976).

The AD & ECI trends in the present study (decreased from 3rd to 5th instar) are corroborated in *C. cupreata* (Ahmad et al. 2002; Gupta and Maleyvar 1981), in *Pieris brassicae* (Sharma et al. 1999) and in *Agrotis orthogonia* and *Bombyx mori* (Waldbaur 1968). However, Kumar and Ahmad (2000) reported an opposite trend of increase in ECI from 3rd to 5th instar in *Orgyia postica* on Paulownia. Slansky and Scriber (1981) described that ECI increased, decreased or underwent little change in insects. In the present study, the decline in ECI may be partly due to concomitant decline in AD.

The ECD was found to be less in first instar larval of *Orgyia postica* feeding on Paulownia and thereafter, it increased in successive instars (Kumar and Ahmad 2000). Although scanty information was available on the variation in ECD, the present findings that increasing ECD during successive larval development are corroborated by earlier workers (Evans 1938 &1939; Mukerji and Guppy 1970 and Bailey 1976). Vats et al. (1977) reported a gradual increase in ECD for young fifth instar larvae of *Pieris brassicae*.

The increase in ECD during successive instars of an insect species is due to the fact that less food was used for energy and more was incorporated into the body matter in older larvae (Kogan and Cope 1974).

References

Ahmad M, Mishra R, Ahmad JM, Pandey R. 2002. Defoliation capability of poplar defoliator, *Clostera cupreata* Butler (Lepidoptera Notodontidae). *Indian Forester*, **128** (12): 1360–1366.

Bailey CG, Singh NB. 1977 An energy budget for *Mamestra configurata* (Lepidoptera Noctuidae). *Canadian Entomologist*, **109**: 687–693.

Bailey CG. 1976. A quantitative study of consumption and utilization of various diets in the Berta armyworm, *Mamestra configurata* (Lepidoptera Noctuidae). *Canadian Entomologist*, **108**: 1319–1326.

Evans AC. 1938. Physiological relationships between insects and their host plants. I. The effect of chemical composition of the plants on reproduction and production of winged forms in *Brevicoryne brassicae* L. (Aphididae). *Annals applied Biology*, **25**: 558–572.

Evans AC. 1939. The utilization of food by the larvae of the buff tip, *Phalera bucephala* Linn. (Lepidoptera). *Proceedings Royal Entomologicdal Society London Series* A, **14**: 25–36.

Gupta SC, Maleyvar RP. 1981. Consumption, digestion and utilization of the leaves of *Rhaphanus sativus* and *Brassica rapa* by larvae of *Pieris brassicae* (Lepidoptera Pieridae). *Acta ent bohemoslov*, **78**: 290–302.

Kogan M, Cope D. 1974. Feeding and nutrition of insects associated with soyabeans. 3.Food intake, utilization and growth in the Soyabean looper, *Pseudoplusia includens*. *Annals Entomological Society America*, **67**: 66–72.

Kumar M, Ahmad M. 2000. Consumption and utilization of leaves of *Paulownia fortunei* by the larvae of *Orgyia postica* Walker (Lepidoptera Notodontidae). *Annals of Forestry*, **8** (2): 192–204.

Mackey AP. 1978. Growth and bioenergetics of the moth *Cyclophragma leucosticte* Grunberg. *Oecologia* (Berln), **32**: 367–371.

Mukerji MK and Guppy GS. 1970. A quantitative study of food consumption and growth in *Pseudaletia unipuncta* (Lepidoptera Notodontidae). *Canadian Entomologist*, **102**: 1179–1188.

Singh P, Prasad G. 1985. Poplar stem borer *Apriona cinerea* Chevrolet (Coleoptera Cerambycidae), its biology, ecology and control. *Indian Forester*, **111**: 517–524.

Slansky FJ, Scriber JM. 1981. The nutritional ecology of immature insects. *Annual Review Entomology*, **26**: 183–211.

Sohi AS. 1990. Insect pests of poplar and their management. In: Rataul HS edited, *Key insect pests of India, their bioecology with special references to integrated pest management.* PAU Ludhiana: Department of Entomology, pp. 295–306.

Thakur ML. 2000. *Forest Entomology* (Ecology and Management). Dehra Dun Utrakhand India: Sai Publishers, pp. 255.

Vats LK, Kaushal BR. 1980. Fluctuation of lepidopteran population, secondary productivity and energy flow through *Belenois mesentina* Cr. (Pieridae). *Agro-Ecosystems*, **6**: 161–176.

Vats LK, Singh JS, Yadava PS. 1977. Food energy budget of *Pieris brassicae* a pest of cruciferous agro-ecosystems. *Agro-Ecosystems*, **3**: 303–312.

Waldbaur GP. 1968. The consumption and utilization of food by insects. *Advances in Insect Physiology*, **5**: 229–282.